FAA General Aviation, Aviation Maintenance, and Vertical Flight Program Review
September 10-11, 2003, Reno, NV

COMPUTER AND BROADBAND TECHNOLOGY IN THE AVIATION MAINTENANCE WORKPLACE

Steve Casner
NASA Ames Research Center

Antonio Puentes
San José State University Foundation

We surveyed the marketplace for computer and broadband technologies and investigated their use at eighteen aircraft maintenance facilities. We documented the use of technology at maintenance facilities through field notes gathered during site visits and telephone interviews. We found deployment of technology at every maintenance facility we surveyed. The extent of technology deployment was determined by size of the company, financial resources, and type of operations. The goal of technology deployment, at every facility, was to reduce operations costs by making more efficient use of existing maintenance resources. Feedback about the technology in use sometimes differed strikingly between managers and maintenance technicians: managers' comments were characterized by cost concerns, while maintenance technicians' comments were largely based on learnability and practical usability of the technology.

INTRODUCTION

As aircraft maintenance organizations recognize the potential cost-savings offered by technologies that store and communicate information in digital format, tech companies have rushed to the marketplace to meet the demand. We researched the marketplace of computer and broadband technologies now offered to aircraft maintenance facilities. Through a series of site visits and telephone interviews, we documented the use of these technologies at eighteen aircraft maintenance facilities.

The following is a summary of a large collection of field notes we gathered during those visits and interviews. We have organized our findings around the kinds of technologies that are now offered. We begin with the most basic of the technology products: digitally-archived documents, and progress our way to the cutting-edge: wireless-networked, wearable computers.

For each type of technology, we discuss:

1) How and why the technology is used
2) Maintenance facilities that use the technology
3) Feedback received from both managers and maintenance technicians about their experiences with the technology.

SOFTWARE TECHNOLOGIES

The first category of aircraft maintenance technology we encountered was software products used to provide managers and technicians with access to documentation, and status information about maintenance work happening within the company.

We identified three kinds of software technologies offered for aircraft maintenance applications:

1) Electronic documentation
2) Maintenance scheduling/tracking/inventory systems
3) Systems built on top of scheduling/tracking/inventory systems

Electronic Documentation

The most basic type of software technology digitally archives and manages the revision process for aircraft maintenance documents. These documents include: maintenance manuals, illustrated parts catalogs, and job cards (cards that spell out specific maintenance procedures).

Electronic documentation represents the foundation, or bottom layer, of the available technology.

Uses:

In its most basic form, electronic documentation is stored on a central database where it is maintained, revised, and updated on schedule. Maintenance technicians access the documentation through a variety of computer hardware devices, all described below.

In addition to providing basic access to documents, advanced features of the electronic documentation systems cross-reference related sections of the electronic maintenance manuals and illustrated parts catalogs, check for updates, and then print job cards that integrate relevant text and graphics drawn from multiple electronic documents.

These features streamline the mechanic's job of gathering paperwork to complete a maintenance task.

Vendors:
Jouve Aviation Solutions is a major supplier of electronic documentation products. Jouve's AirGTI DocManager acts as an intermediary between equipment manufacturers and the maintenance facilities that operate and service the equipment. We found Jouve systems in use at eleven of the eighteen maintenance facilities we interviewed.

Some individual aircraft manufacturers, such as Boeing and Bombardier, offer their own products. Boeing's BOLD (Boeing On-Line Data) system offers all of the same kinds of documents, including service bulletins and parts lists, for the Boeing fleet. We found several facilities using these products, sometimes in addition to the Jouve Aviation products.

Electronic documentation proved to be the most widely-accepted and deployed type of technology. We found electronic documentation being used at every maintenance facility we contacted.

Feedback:
We received positive comments about electronic documentation from everyone we interviewed. There seemed to be universal agreement about the benefits of electronic documentation among both managers and maintenance technicians. Interviewees cited specific reasons cited for their favorable attitudes toward electronic documentation:

(1) Technicians liked how the computer allowed them to open several documents at once – something not achievable flipping through pages of a paper manual.
(2) Technicians liked how related documents were often linked. This represented a significant time savings over having to search through tables of contents and indices.
(3) Managers stressed the ease and frequency that they were able to accomplish updates and revisions. The plug-and-play capabilities of the computer enables them to do updates every 14 days.
(4) The time required to accomplish updates and revisions is now hours instead of days.

Maintenance scheduling/tracking/inventory systems
A second type of software technology helps to manage all aspects of maintenance work, for individual aircraft, company wide.

Uses:
This technology computerizes:

1) Scheduling of future maintenance checks, or delayed MEL items.
2) Scheduling of maintenance personnel.
3) Ordering and inventory of parts
4) Life expectancy and actual life of parts
5) Hand-off of maintenance work from one crew to another.

This type of software management system is capable of coordinating the collocation of aircraft, needed parts, and maintenance personnel, at a scheduled place and time.

Vendors:
Hundreds of companies offer work management and scheduling software. Aviation Maintenance [1] published a review of the state-of-art systems offered as of 1999. Two systems we encountered frequently were MRO Software's Maximo product, and Sabre Technology Solution's Maxi-Merlin system.

Feedback:
The feedback we received from managers was overwhelmingly positive, as these systems automate many of the tasks required to coordinate a maintenance effort.

Maintenance technicians were somewhat indifferent toward this type of technology, and focused more on the practical aspects of the interface between maintenance worker and the computer that implemented the system. They sometimes complained about the computer interfaces being older or lacking in usability. Maintenance technicians typically mastered the specific functions they needed to use and paid little attention to the rest of the system.

Systems built on top of scheduling/tracking/inventory systems
A third type of technology we encountered were systems that had been built on top of existing scheduling/tracking/inventory systems. These systems use the core features of a scheduling/tracking/inventory system and extend its features.

One company we visited has made significant investments in this type of technology. One customized system in use displays a graphical map of all aircraft on ramp and their status. These displays are located in the ramp controller's tower on the

airport. An air-to-ground communications system (discussed below) allows airplanes to communicate with the ramp controller. The displays feature a color coding scheme that allows controllers to quickly scan an entire ramp and assess the status of all aircraft (e.g., Red = aircraft taxiing; Blue = engines lit, beacon on).

The same company is developing a number of systems that will provide paperless aircraft logs, video conferencing capabilities, and video training aids. None have been implemented at this time.

This company is also exploring the idea of a system that will archive case-based troubleshooting tips for maintenance incidents. Their prime concern is that the age distribution among maintenance technicians will result in a loss of a significant proportion of their experienced workforce. Such a system would help preserve expertise in the company as expert technicians retire in numbers.

HARDWARE TECHNOLOGIES

The second category of aircraft maintenance technology we encountered was hardware devices used to provide managers and technicians with access to the software systems described above.

Computer workstations

The most basic type of hardware system we found were computer workstations that are typically located on the shop floor.

Uses:

Computer workstations were used almost exclusively by maintenance technicians and inspectors. Workstations typically have printers connected to them, allowing technicians to print out pages and carry them to the aircraft.

Feedback:

The feedback we received from maintenance technicians about the computer workstations was generally positive:

1) Technicians liked how the workstations support multiple users. When several workstations are available, there is no need to wait to access a single paper copy of a manual.
2) Technicians mentioned the time spent walking back and forth between workstation and aircraft.
3) When only a few workstations were available, technicians sometimes had to wait to access the needed documentation, in the same way they did when paper manuals were used.

Portable/wearable computers and wireless networks

The most advanced type of hardware technology was the portable or wearable computer that communicates with a central server via a wireless network. The wireless network consisted of a central computer and a series of RF antennas places around the worksite to permit line-of-sight communications between central computer and portable computer anywhere on the ramp or shop floor.

We encountered three kinds of portable computers:

1) Laptop computers
2) Personal data assistants
3) Pen-based tablet computers

Some computers include harnesses that allow them to be worn, keeping the technicians' hands free to do work.

Uses:

The most basic use of the portable computer was as a vehicle for the electronic documents described above – maintenance manuals, illustrated parts catalogs, etc. One major airline carrier we interviewed gave portable computers to their line maintenance inspectors who did walk-arounds on arriving aircraft. The computers are used to write up and quickly distribute squawks.

Portable computers also provide technicians with access to the scheduling/tracking/inventory systems described above. Technicians can make log entries, fill out work cards, send and receive maintenance alerts, and communicate with other technicians.

Vendors:

Xbernaut Corporation offers the Xbernaut Mobile Assistant. Via Incorporated offers the Via II PC. Several companies offer personal data assistant (PDA) computers. We found none of the custom-made wearable computer systems [2, 3] in use at any facility we visited.

Feedback:

Portable computers and wireless networks represented the most diverse comments we received from managers and maintenance technicians.

Managers were enthusiastic about the technology and seemed to be impressed by the technological capabilities. A quote from one company manager summed up a popular complaint among many companies: "We can't get our guys to use them."

Maintenance technicians often complained about their portable computers. One line maintenance

technician pointed to an idle laptop computer sitting on top of an aircraft tug and said: "I never touch the thing." Specific complaints about the portable computers included:

1) The wireless RF networks were often intermittent. When the RF network didn't function, the whole system was unusable.
2) Wireless networks still offer slow transfer rates. Multiple users often compete for signal, and transfer rates are degraded.
3) The screens on the portable computers were often too small or offered too low of a resolution.
4) Batteries often ran out at inconvenient times.
5) The portable computers had durability problems when subjected to hard use on the shop floor. More rugged computers are available but at much higher cost.
6) Less 'computer savvy' technicians find them difficult to learn and use.

Some maintenance technicians were very opposed to the idea of replacing computer workstations with portable computers (e.g., "Don't you dare take it away from me.")

One company surveyed the attitudes of their maintenance technicians toward portable/wearable computers. They found that 16% of technicians rated the computers "easy to use," while a total of 59% found it at least "acceptable." 75% of technicians said they would consider using the device.

Positive comments from maintenance technicians about wireless networks were that it enabled problems to be forwarded to maintenance facility for immediate action when aircraft land.

Other Wireless Technologies

We encountered a few other kinds of wireless communications networks.

Cockpit computers

Spirent Systems offers an Onboard Maintenance System that provides real-time fault detection on board an aircraft in flight. The OMS is capable of detecting faults that are not presented to the crew in the form of alert messages. For example, each pitot tube contains two heating elements. The crew will not see a NO PITOT HEAT message unless both heating elements become inoperative.

One airline has installed server computers on board its aircraft that can store electronic documentation as well as data collected from an Onboard Maintenance System. Their system contains an interface that pilots can use to make inputs and entries.

Cockpit to floor

The same airline has implemented a wireless local area network technology that allows the servers installed in the airplanes to communicate with ground servers once the aircraft is parked and the doors are disarmed. Once a connection is established, the ground server updates the aircraft maintenance manual and the flight operations manual as required. The aircraft server then downloads the flight manifest and any fault information registered by the Onboard Maintenance System or the crew.

Air-to-ground

The existing ACARS system is used by some carriers to transmit fault information to the company ground servers while an aircraft is still in flight. This allows line maintenance crew to be prepared when any aircraft lands. One company reports that their air-to-ground communication system avoids roughly 90 delays per year.

One corporate aircraft maintenance facility related a story of a Gulfstream G-V, flying at FL510 over the Pacific Ocean, that experienced a windshield crack. The maintenance facility located the needed windshield at a west coast facility, arranged for technicians to be on the ground at the airplane's ETA, and then directed the aircraft to that facility, where the work was completed with minimum ground time.

The stated goal of all of the air-to-ground wireless technologies is "to eliminate unscheduled maintenance."

CONCLUSION

We found computer and broadband technologies in use at all eighteen aircraft maintenance facilities that we surveyed. We found the available technology to be offered in layers, allowing maintenance facilities to gradually implement new systems on their own schedules. We found a wide interesting in implementing computer and broadband technologies, as well as large and growing number of vendors that offer the technologies.

The comments we received suggest that the deployment of technology has been driven by management in an effort to cut operations costs.

The feedback we received from managers and maintenance technicians we generally positive, with one exception: managers were enthusiastic about portable and wearable computer systems, whereas, maintenance workers were not. Managers' comments were driven by concerns of company-wide costs, while technicians were concerned with practical usability of the computers.

Perhaps the most striking feature of the comments we received was that there was little discussion of how computer and broadband technologies impact or relate to *safety*. In no case did a maintenance technician make reference to any technology helping them find or resolve a maintenance problem that they would not have found or resolved otherwise. Rather, the technology was seen as an aid to more efficiently and economically using their existing maintenance resources.

We searched for the character string "safe" in all documents we collected, including: magazine articles, presentations, product information sheets, and our interview notes. Only one product information sheet contained the word "safety."

REFERENCES

[1] "Automating Aviation." (1999). Aviation Maintenance, October. Available on-line: http://www.aviationtoday.com/reports/avmaintenance/previous/october99/am10computer.htm

[2] Barfield, W., and Caudell, T. (2001). *Fundamentals of wearable computers and augmented reality*. Lawrence Erlbaum Associates.

[3] Smailagic, A., Siewiorek, D. P. (1996). Modalities of interaction with CMU wearable computers. IEEE Personal Communications 3 (1): 14-25.